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DESCRIPTION

ERROR SIGNAL GENERATION DEVICE

Technical Field

The present invention relates to a technology for generating various kinds of servo error signals in optical disk recording/reproduction devices.

Background Art

Error signal generation devices in conventional optical disk devices perform detection of reflected light or transmitted light of light beam from an optical disk and a differential operation of detected information to generate error signals. Further, a gain balance is applied to each detected signal to correct a sensitivity difference in photodetecting means (see Japanese Patent Application Laid Open Publication No. 8-50726.).

FIG. **20** is a block diagram of an optical disk device using a conventional error signal generation device **200**. Reference numeral **201** denotes an optical disk and **202** denotes a light beam irradiation unit for irradiating light beam to the optical disk **201**. **203** denotes a photodetection unit composed of a plurality of photodetectors for detecting reflected light or transmitted light of light beam from the optical disk **201**. **204** denotes an error source signal generation unit that generates two signals to be sources of an error signal from a plurality of outputs from the photodetection unit **203**.

The error signal generation device **200** generates an error signal from outputs of the error source signal generation unit **204**. **205** denotes an adjustment unit that applies a gain and an offset to two signals, which are to be sources of an error signal, from the error source signal generation unit **204**. **206** denotes a balance operation unit that performs a differential operation by applying a gain balance to two outputs from the adjustment unit **205**.

In the above conventional technology, in the case where a dynamic range (D

range) on the output side of the adjustment unit **205** immediately thereafter is limited, the values of the gain and the offset of the adjustment unit **205** are set so that the amplitude of each output signal of the adjustment unit **205** falls within the D range. While, in the case dealing with a signal that is offset between in a focused mode and in an unfocused mode, the amplitude of output signals of the adjustment unit **205** in the focused mode becomes small with respect to the D range and the amplitude of an error signal after the differential operation by the balance operation unit **206** becomes small, whereby error signal accuracy is lowered.

Summary of the invention

The present invention has its object of obtaining a highly accurate error signal even in the case dealing with a signal that is offset between in a focused mode and in a unfocused mode in an optical disk device.

In the present invention, the offset amount of a signal in the unfocused mode is obtained by referencing an operation reference level of a balance operation, only the signals in the focused mode are subjected to the balance operation, and then, correction corresponding to the offset amount is performed. This makes it possible to utilize the D range to the maximum, with a result of increase in accuracy of error signals.

Brief Description of the Drawings

FIG. **1** is a block diagram of an optical disk device using an error signal generation device according to the present invention.

FIG. **2** is a diagram showing an error signal generating operation in the error signal generation device in FIG. **1**.

FIG. **3** is a schematic view showing an input signal adjusting operation in the error signal generation device in FIG. **1**.

FIG. **4** is a detailed view showing the input signal adjusting operation in the error signal generation device in FIG. **1**.

FIG. **5** is a view showing an example of the inside structure of a balance correction

value adjustment unit in FIG. **1**.

FIG. **6** is a view showing another example of the inside structure of the balance correction value adjustment unit in FIG. **1**.

FIG. **7** is a view showing still another example of the inside structure of the balance correction value adjustment unit in FIG. **1**.

FIG. **8** is a view showing yet another example of the inside structure of the balance correction value adjustment unit in FIG. **1**.

FIG. **9** is a view showing an offset adjusting operation in the error signal generation device in FIG. **1**.

FIG. **10** is a view showing an example of the structure of a signal measurement unit in FIG. **9**.

FIG. **11** is a view showing another example of the structure of the signal measurement unit in FIG. **9**.

FIG. **12** is a view showing still another example of the structure of the signal measurement unit in FIG. **9**.

FIG. **13** is a view showing a gain adjusting operation in the error signal generation device in FIG. **1**.

FIG. **14** is a view showing another gain adjusting operation in the error signal generation device in FIG. **1**.

FIG. **15** is a view showing an example of the structure of a signal measurement unit in FIG. **13** and FIG. **14**.

FIG. **16** is a view showing another example of the structure of the signal measurement unit in FIG. **13** and FIG. **14**.

FIG. **17** is a view showing a calibration operation in the error signal generation device in FIG. **1**.

FIG. **18** is a view showing a gain calibration operation in the error signal generation device in FIG. **1**.

FIG. **19** is a view showing an offset calibration operation in the error signal generation device in FIG. **1**.

FIG. **20** is a block diagram of an optical disk device using a conventional error signal generation device.

Detailed Description of the Invention

Embodiments of the present invention will be described hereinafter with reference to accompanying drawings.

FIG. **1** is a block diagram of an optical disk device using an error signal generation device **100** according to the present invention. Reference numeral **101** denotes an optical disk, **102** denotes a light beam irradiation unit for irradiating light beam to the optical disk **101**. **103** denotes a photodetection unit composed of a plurality of photodetectors for detecting reflected light or transmitted light of light beam from the optical disk **101**. **104** denotes an error source signal generation unit that generates two signals to be sources of an error signal from a plurality of outputs from the photodetection unit **103**. **105** denotes a focus monitoring unit that detects, from a plurality of outputs from the photo detection unit **103,** whether a focal point of light beam is focused on the optical disk **101**.

The error signal generation device **100** generates an error signal from outputs from the error source signal generation unit **104**. Reference numeral **106** denotes an adjustment unit that applies an offset and a gain to two signals, which are to be sources of an error signal, from the error source signal generation unit **104**. **107** denotes a balance operation unit that performs a differential operation by applying a gain balance to two outputs from the adjustment unit **106**. **108** denotes a signal measurement unit that measures two outputs from the adjustment unit **106**. **109** denotes an offset amount learning unit that measures each offset amount in an unfocused mode of the two outputs of the adjustment unit **106** offset from an operation reference level of the balance operation unit **107**, according to a signal indicating a light beam convergence state from the focus monitoring unit **105** and the measured results of the signal measurement unit **108**. **110** denotes a balance correction

value adjustment unit that determines a correction value in the balance operation according to information on a balance value from the balance operation unit **107** and the offset amount in the unfocused mode from the offset amount learning unit **109**. **111** denotes a balancer correction unit that adds information on the correction value of the balance correction value adjustment unit **110** to an output of the balance operation unit **107**.

FIG. **2** shows an error singal generating operation in the error singal generating device **100** in FIG. **1**. The signal measurement unit **108** measures each offset amount (a, b) in the unfocused mode of outputs of the adjustment unit **106** offset from the operation reference level of the balance operation unit **107**. In the balance correction value adjustment unit **110**, a correction value is determined according to the measured offset amounts a and b and a balance value Bal used in the balance operation. The balancer correction unit **111** performs correction of the balance operation by adding the correction value determined by the balance correction value adjustment unit **110** to an output result of the balance operation unit **107**. Hence, the balance operation can be performed with high accuracy even for a signal having an offset amount in the unfocused mode.

As described above, in the error signal generation device **100** in FIG. **1**, each offset amount in the unfocused mode of input signals offset from the balance operation reference level is obtained, only the signals in the focused mode are subjected to the balance operation, and then, correction corresponding to the obtained offset amounts is performed. Thus, the balance operation can be performed even when a singal in the unfocused mode does not exceed the balance operation reference level of the balance operation. In other words, the D range is utilized widely in the focused mode, with a result of increase in error signal accuracy.

The error signal generation device **100** in FIG. **1** will be described further in detail hereinafter with reference to FIG. **3** through FIG. **19**.

FIG. **3** schematically shows an input signal adjusting operation in the error signal generation device **100** in FIG. **1**. In FIG. **3**, the D range on the output side of the

adjustment unit **106** immediately thereafter is limited to a given value. Each gain and offset amount of the adjustment unit **106** is determined in accordance with to the output side D range beforehand so that signals after the adjustment fall within the D range. There may be a case where an A/D converter or the like is provided on the output side of the adjustment unit **106** immediately thereafter and the D range is limited to a given value by the thus provided A/D converter or the like. However, it is possible to perform the balance operation by adjusting the input signals to fall within the D range even in such the case where the A/D converter or the like limits the D range before the balance operation.

FIG. **4** shows in detail the input signal adjusting operation in the error signal generation device **100** in FIG. **1**. In FIG. **4**, the offset amount learning unit **109** performs adjustment of an offset and a gain of the adjustment unit **106** twice, namely, in the focused mode and in the unfocused mode, and calculates an offset amount of a signal in the unfocused mode with the gain and the offset in the focused mode according to the offset amount in the unfocused mode and each set value of the gain and the offset in the focused mode and in the unfocused mode. The expression for the calculation is expressed as $(a\text{-}Ofs1)/G1 \times G2+Ofs2$, wherein a is an offset amount in the unfocused mode, G1 is a set gain value in the focused mode, Ofs1 is a set offset value in the focused mode, G2 is a set gain value in the unfocused mode and Ofs2 is a set offset value in the unfocused mode. It is possible to set the gain and offset values in the focused mode so that output signals of the adjustment unit **106** in the unfocused mode exceed the D range on the output side of the adjustment unit **106**.

In FIG. **4**, since the offset amount of an input signal in the unfocused mode is obtained according to the respective set values of the gain and the offset of the adjustment unit **106** in the focused mode and in the unfocused mode, the signals in the unfocused mode exceed the output side D range, so that the D range is widely utilized and the balance operation can be performed with high accuracy.

FIG. **5** shows an example of the inside structure of the balance correction value

adjustment unit **110**. The balance correction value adjustment unit **110** in FIG. **5** sets, using two outputs (a, b) of the offset amount learning unit **109** and the balance value (Bal) of the balance operation unit **107**, the correction value in the balance operation to a(1+Bal)-b(1-Bal). Thus, the correction value in the balance operation is re-calculated and corrected correspondingly to dynamic variation of the balance value (Bal), thereby always achieving the balance correction with high accuracy. In addition, the balance operation unit **107** and the balance correction value adjustment unit **110** can use a processor in common.

FIG. **6** shows another example of the inside structure of the balance correction value adjustment unit **110** in FIG. **1**. The balance correction value adjustment unit **110** in FIG. **6** sets, using two outputs (a, b) of the offset amount learning unit **109** and the balance value (Bal) of the balance operation unit **107**, the correction value in the balance operation to Bal(a+b)+(a-b). This makes it possible to reduce the number of processors in the balance correction value adjustment unit **110**, resulting in increase in operation speed.

FIG. **7** shows still another example of the inside structure of the balance correction value adjustment unit **110** in FIG. **1**. The balance correction value adjustment unit **110** in FIG. **7** sets, using the balance value (Bal) of the balance operation unit **107**, the correction value in the balance operation to Bal(a+b) when two outputs (a, b) of the offset amount learning unit **109** are sufficiently great and the difference between a and b is small. This makes it possible to reduce the number of processors in the balance correction value adjustment unit **110**, resulting in increase in operation speed.

FIG. **8** shows yet another example of the inside structure of the balance correction value adjustment unit **110** in FIG. **1**. For the balance correction value adjustment unit **110** in FIG. **8**, the same gain and offset values are applied to two inputs of the adjustment unit **106** so that the offset amount learning unit **109** outputs a common value (a) of the two outputs. Then, the balance correction value adjusting unit **110** sets, using the balance value (Bal) of the balance operation unit **107**, the correction value in the balance operation to $2 \times \mathrm{Bal} \times a$. The common gain and offset values of the adjustment unit **106** reduces the number

of processors, resulting in increase in operation speed.

FIG. **9** shows an offset adjusting operation in the error signal generation device in FIG. **1**. The singal measurement unit **108** in FIG. **9** measures a mean value of output signals of the adjustment unit **106** in the unfocused mode and in the focused mode. The offset amount learning unit **109** determines an offset value of the adjustment unit **106** so that the thus measured mean value becomes the operation reference level of the balance operation. This makes it possible to perform the balance operation with high accuracy even in the case where the offset amount of an input signal depends on the optical disk **101** for performing recording and reproduction, the focal point of light beam on the optical disk **101** or the like.

FIG. **10** shows an example of the structure of the signal measurement unit **108** in FIG. **9**. The signal measurement unit **108** in FIG. **10** measures a time average of output signals of the adjustment unit **106** in the unfocused mode and in the focused mode and sets the thus obtained time average as a mean value of the output signals of the adjustment unit **106**. This makes it possible to realize the signal measurement unit **108** by a simple processor.

FIG. **11** shows another example of the structure of the signal measurement unit **108** in FIG. **9**. The signal measurement unit **108** in FIG. **11** measures a maximum value and a minimum value of output signals of the adjustment unit **106** in the unfocused mode and in the focused mode and sets an intermediate value between the maximum value and the minimum value as a mean value of the output signal of the adjustment unit **106** in the focused mode. This makes it possible to perform the balance operation with high accuracy even in the case where the amplitude center is different from the time average because of the signal biased.

FIG. **12** shows still another example of the structure of the signal measurement unit **108** in FIG. **9**. The signal measurement unit **108** in FIG. **12** measures a maximum value and a minimum value of output signals of the adjustment unit **106** in the unfocused

mode and in the focused mode within a given time period, repeats this measurement plural times, and then, sets an intermediate value of the respective measured values as a mean value of the output signal of the adjustment unit **106** in the focused mode. This makes it possible to perform the balance operation with high accuracy with no noise influence involved.

FIG. **13** shows a gain adjusting operation in the error signal generation device **100** in FIG. **1**. The signal measurement unit **108** in FIG. **13** measures the amplitude of an output signal of the adjustment unit **106** in the focused mode. The offset amount learning unit **109** determines the gain value of the adjustment unit **106** so that the amplitude of the output signal of the adjustment unit **106** in the focused mode becomes a fixed ratio with respect to the D range on the output side of the adjustment unit **106** immediately thereafter. For example, the offset amount learning unit **109** determines the gain value of the adjustment unit **106** according to a ratio between the amplitude of the output signal of the adjustment unit **106** and the D range immediately after the output of the adjustment unit **106**. Specifically, the gain value of the adjustment unit **106** may be determined so that the amplitude of an output signal of the adjustment unit **106** in the focused mode becomes about 80 % of the D range on the output side of the adjustment unit **106** immediately thereafter.

According to FIG. **13**, the balance operation can be performed with high accuracy even in the case where the amplitude of an input singal depends on the optical disk **101** for performing recording and reproduction, the focal point of light beam on the optical disk **101** or the like. In addition, the balance operation can be performed with high accuracy within the D range even when the amplitude of an input signal varies dynamically.

FIG. **14** shows another gain adjusting operation in the error signal generation device **100** in FIG. **1**. The offset amount learning unit **109** in FIG. **14** sets the gain value of the adjustment unit **106** to be minimum and increases gradually the thus set gain value of the adjustment unit **106** until the amplitude of an output signal of the adjustment unit **106**

thereafter exceeds a given rate of the D range on the output side of the adjustment unit **106** immediately thereafter, thereby adjusting the gain value of the adjustment unit **106**. In so doing, the balance operation can be performed with high accuracy even with an error in the set gain and offset values of the adjustment unit **106**.

FIG. **15** shows an example of the structure of the singal measurement unit **108** in FIG. **13** and FIG. **14**. The signal measurement unit **108** in FIG. **15** measures a maximum value and a minimum value of output signals of the adjustment unit **106** in the focused mode, and sets the difference between the maximum value and the minimum value as the amplitude of the output singal of the adjustment unit **106**. In so doing, the signal measurement unit **108** can be realized by a simple processor.

FIG. **16** shows another example of the structure of the signal measurement unit **108** in FIG. **13** and FIG. **14**. The signal measurement unit **108** in FIG. **16** measures a maximum value and a minimum value of output signals of the adjustment unit **106** in the focused mode within a given time period, performs this measurement plural times to obtain respective mean values of the maximum values and the minimum values, and then, sets the difference between the thus obtained mean values as the amplitude of the output signal of the adjustment unit **106**. In so doing, the balance operation can be performed with high accuracy even in the case where the amplitude center is different from the time average because of the signal biased.

It is noted that the gain value of the adjustment unit **106** may be determined beforehand according to a kind of a medium used in the optical disk **101**. In so doing, the error signal generating apparatus **100** can be realized easily.

FIG. **17** shows a calibration operation in the error signal generation device **100** in FIG. **1**. In FIG. **17**, the calibration of the gain and offset amounts is performed by adjusting the set gain and offset values of the adjustment unit **106** by the offset amount learning unit **109** when there is an error between the set gain and offset values of the adjustment unit **106** and actual gain and offset amounts. In so doing, the balance operation can be

performed with high accuracy even if there is an error between the set gain and offset values of the adjustment unit **106** and actual gain and offset amounts.

FIG. **18** shows a gain calibration operation in the error signal generation device **100** in FIG. **1**. In FIG. **18**, a gain variation amount with respect to the set gain value is calculated in a manner that the offset amount learning unit **109** changes the gain of the adjustment unit **106** in the unfocused mode while the offset amount is fixed and the signal measurement unit **108** measures variation in the mean value of output signals of the adjustment unit **106**. This attains the structure shown in FIG. **17** with a simple algorithm.

FIG. **19** shows an offset calibration operation in the error signal generation device **100** in FIG. **1**. In FIG. **19**, an offset variation amount with respect to the set offset value is calculated in a manner that the offset amount learning unit **109** changes the offset of the adjustment unit **106** in the unfocused mode while the gain amount is fixed and the signal measurement unit **108** measures variation in the mean value of output signals of the adjustment unit **106**. This attains the structure shown in FIG. **17** with a simple algorithm.

Industrial Applicability

As described above, the error generating device according to the present invention can utilize the D range to the maximum in the focused mode, whereby error signal accuracy is increased. Thus, the present invention is useful for optical disk recording/reproduction devices and the like.